and he found that blocking that position by adding a side branch would increase the oxidative stability. Unfortunately, this had the effect of making the oil very sluggish at low temperatures. To counteract this, he put the branch a little further down the chain, which improved the viscosity at low temperatures but did not hurt the oxidative stability. "It gets down to the fundamental mechanisms of oxidation," Sutor says.

Researchers are also trying to understand the fundamental properties of solid lubricants with an eye toward improving their performance too. Solid lubricants, such as graphite or molybdenum disulfide (MoS_2), do not reduce friction as well as oils, nor do they perform some of the other jobs of liquid lubricants, such as distributing heat, carrying additives, or collecting dirt for filtration. They are the lubricant of choice, however, in extreme conditions where liquids will not work, such as in very high temperatures or the near vacuum of outer space.

To predict the lubricating ability of a solid, says tribologist Irwin Singer of the Naval Research Laboratory in Washington, D.C., one must understand the interactions between two surfaces and a lubricant as they rub against each other. The motion, heat, and pressure generated in the contact zone cause chemical reactions between the lubricant, the surfaces, and the oxygen in the atmosphere, creating a variety of chemical compounds. These compounds may help or hurt the lubricating action, depending on their structure, so it's important to know what compounds are formed.

Singer and his colleagues have analyzed the solid lubricant MoS_2 in contact with steel and ceramic surfaces. Simple chemistry is enough to predict which compounds will be formed in the contact zone, he says. There are only a finite number of possibilities, and the ones that appear are the ones that are most stable; determining the most stable candidates is a matter of finding the ones with the highest free energy of formation, Singer says. He has checked his predictions by doing experiments with the various materials and then using an electron microscope to determine which compounds were formed in the contact area.

"A good metallurgist could have done this 30 years ago if he had had all the thermodynamic data," Singer says, "but no one has ever done these experiments." Until recently, most tribologists were content to do empirical work without looking at the molecular level to make testable predictions. "What's exciting about it is, it now gives some guidance on how to design lubricants without having to guess," he says.

■ ROBERT POOL

Gene-Transfer Method Fails Test

If science is self-cleansing, then a concerted effort by a number of biologists seems to have mopped up any hope of a new, easy method for putting foreign genes into mice. When Corrado Spadafora reported last June that genes could be transferred by fertilizing mouse eggs with sperm that had been mixed with DNA, researchers around the world began to try to repeat the potentially revolutionary technique. Now, eight of those teams have reported in *Cell* that they cannot, leaving Spadafora, in the same issue, still standing by the work.

The method reported by Spadafora and his colleagues at the University of Rome in the 2 June issue of *Cell* seemed far simpler than the egg injection procedure normally used for making transgenic mice, as mice bearing foreign genes are called. In fact, it seemed a bit too good to be true. And that is what the letter from transgenic mouse pioneer Ralph Brinster of the University of Pennsylvania now says.

In the 20 October issue of *Cell*, Brinster and colleagues report negative results from their laboratory and summarize similar results sent to them by seven other groups. "We believe it is much more difficult to obtain transgenic animals by the incubation of sperm with DNA than reported," the letter states.

"Usually, negative data do not show up anywhere, but in this case at least you have it documented," says Erwin Wagner of the Institute of Molecular Pathology (IMP) in Vienna, whose findings are included in the letter. Although IMP director Max Birnstiel wrote a supportive commentary that accompanied Spadafora's original paper, Wagner says his laboratory's efforts have shown not a glimmer of success. All told, the eight groups analyzed more than 1300 mice generated with the Spadafora technique and found none to carry foreign DNA.

News of difficulty in replicating Spadafora's experiment has been circulating in the transgenic mouse community since mid-summer (see *Science*, 11 August, p. 590). Wagner, who was organizing a mouse molecular genetics meeting to be held in Heidelberg at the end of August, invited Spadafora and his coauthor, Marialuisa Lavitrano, to chair a forum on the technique. They declined—a disappointment, Wagner says, since he had been hoping they could directly address questions about the technique.

Brinster's collaborator, Richard Palmiter of the University of Washington, chaired the session instead and read the letter he and Brinster were preparing to send to *Cell*. When other groups reported negative findings as well, Palmiter invited them to fax their results to Brinster for inclusion in the letter. The data from other groups strengthen the letter, he says. "The point is that lots of different people, doing [the technique] their own way, were unable to reproduce it."

Neither the authors of the letter nor the participants in the Heidelberg forum have declared Spadafora's work erroneous. But it is not repeatable from the information given in the paper, says Brinster, whose group even used reagents borrowed from Spadafora. It is up to Spadafora now, they say, to repeat the technique and teach others how.

That is what Spadafora pledges to do. Although he did not respond to repeated phone calls from *Science*, the 20 October *Cell* also carries a letter in which Spadafora and his colleagues promise to scrutinize their procedure and share any insights about critical steps. They say they have found no reason yet to doubt the experiments, and they rule out a possible mix-up in which traditionally produced transgenic mice might have been confused with those made by the sperm technique. They report that they have begun efforts to replicate the experiments, both in Spadafora's laboratory and elsewhere, and they are further examining the process by which sperm take up DNA. "Although, still in progress, all this work is consistent with previous results that sperm cells may act as vectors for foreign DNA," their letter says.

At a conference at Cold Spring Harbor's Banbury Center last week, Spadafora reportedly told participants that he suspects that the treatment of the sperm may be critical and that reported differences in the fertility of the sperm after treatment suggest that other labs may be performing that part of the procedure incorrectly. "He is very sincere and concerned," said a participant in the Banbury Center conference who requested anonymity. "He is systematically going through all the experiments again, trying all the variables. You can tell he's a bit nervous." ■ MARCIA BARINAGA